

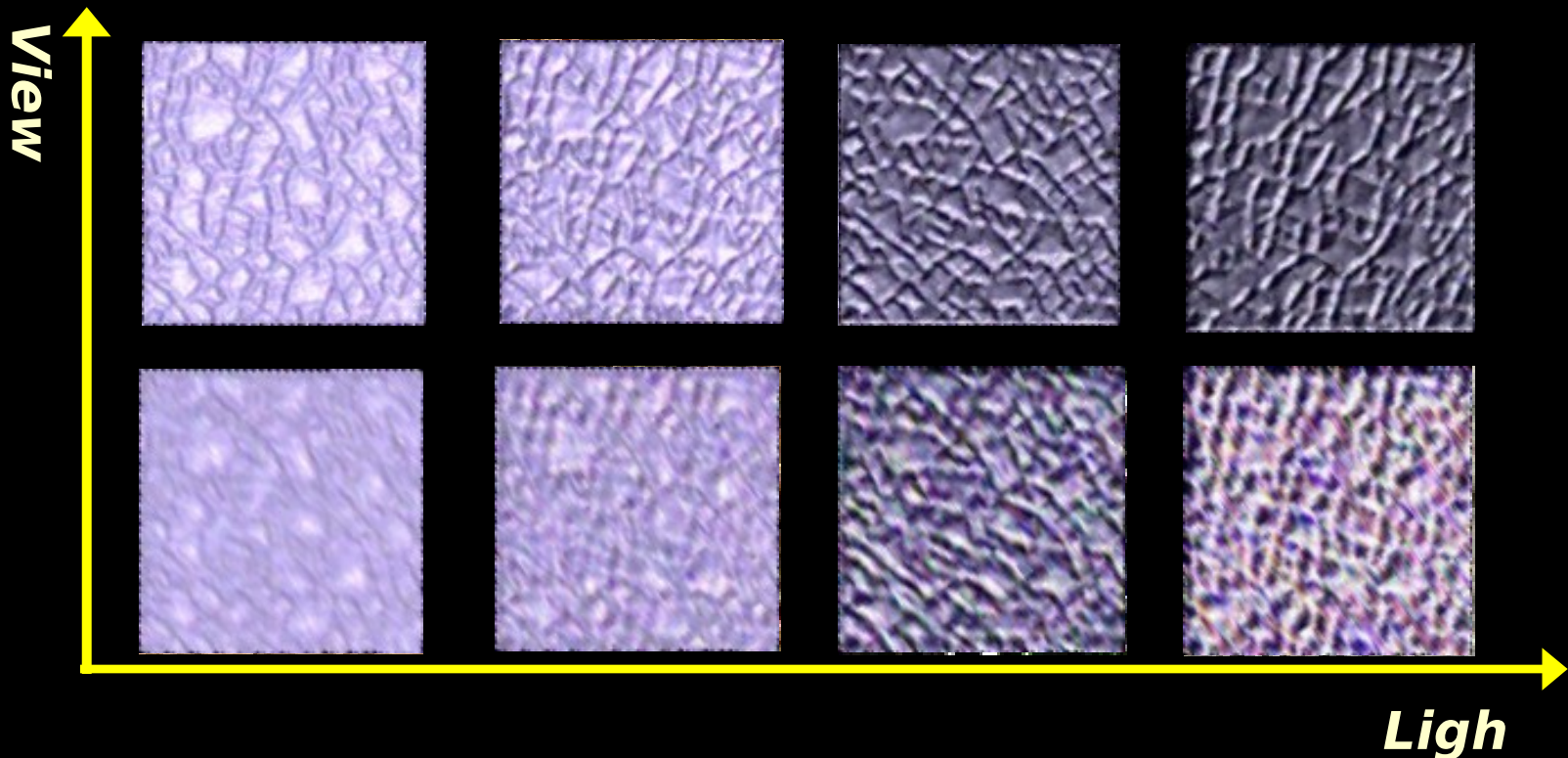
# Synthesis of Bidirectional Texture Functions on Arbitrary Surfaces

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# ***Real World Texture from CuRet***



- Geometry Details (Mesostructure) on Surface
- Self-Occlusion, Self-Shadow, and Specularity

# ***Bidirectional Texture Functions (BTF)***

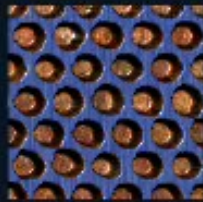
**A collection of images of the same surface under different lighting and viewing directions.**

**— *[Dana et. al. 97]***

- 6D Function (  $x, y, l_\theta, l_\phi, v_\theta, v_\phi$  )
- Dense Sampling in Viewing/Lighting Directions
- Capturing Appearance of Real World Surface

# 2D Texture Map vs. BTF

Surface Texture

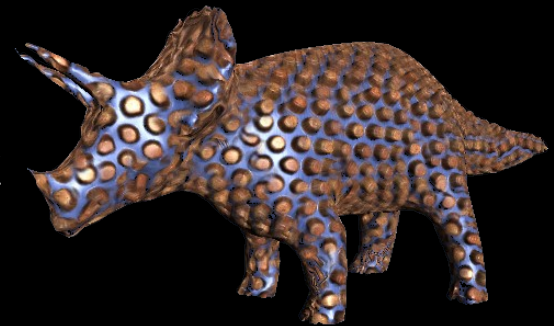
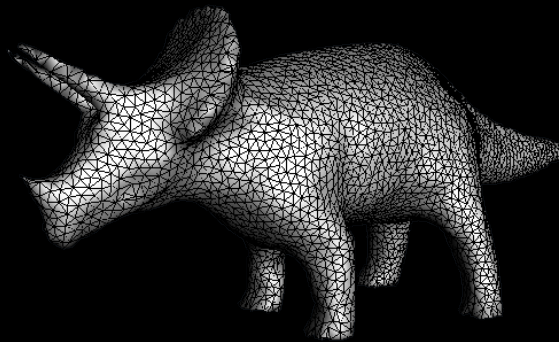


Surface BTF



# ***BTF Synthesis on Surface***

**Given a BTF sample ( a dense set of images ) and a triangle mesh, how can we synthesize the BTF over the mesh surface?**



***Input  
BTF***

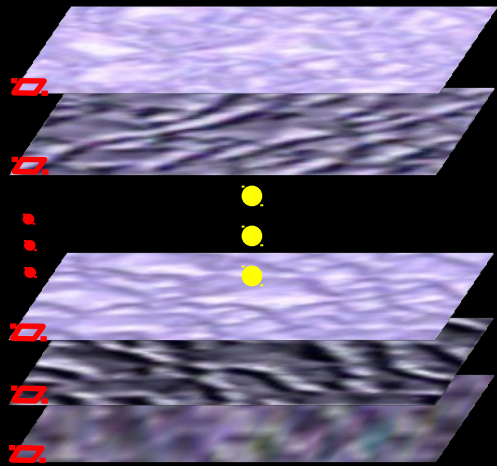
***Input  
Mesh***

***Result***

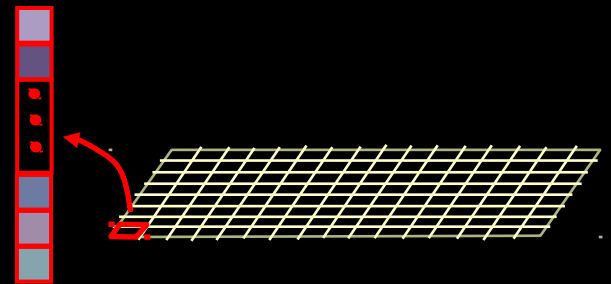
# ***Desirable Properties***

- Good Quality
  - Similar to BTF samples for all lighting/viewing
- Preserve Consistent Underlying Geometry
  - Consistent appearance variation
- Minimal Distortion and High Efficiency
  - Take advantage of algorithms for 2D texture
  - [Wei & Levoy 01], [Turk 01], [Ying et. al. 01]

# Treating BTF as a 2D Texture Map



$$12 \times 5 \times 12 \times 5 = 3600$$

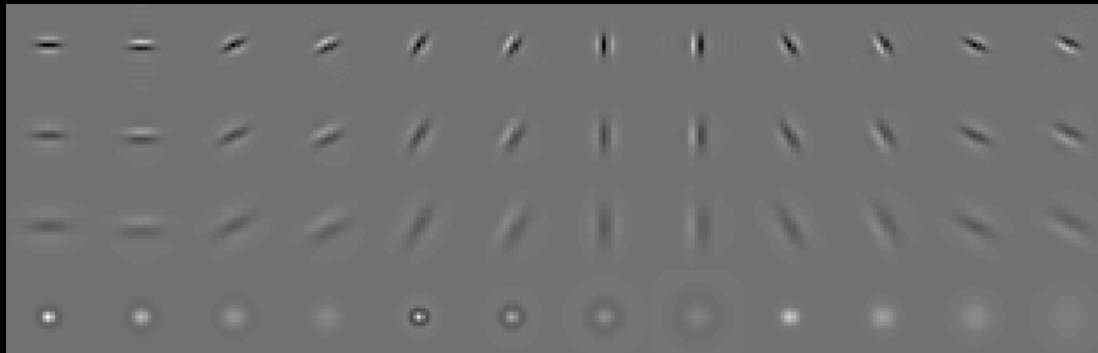


**10800-dimensional  
vector**

**Surface Texton**

# ***3D Texton [Leung & Malik 1999]***

- Capturing Microstructures and Reflectance Variations in BTF
  - Keeping consistent geometry
- Represented by Filter Bank Responses Vector (Appearance Vector)
  - Using 48 Gaussian derivative filters for each



# ***Why Not 3D Texton for Synthesis?***

- **Problem**

- Appearance vector is high dimensional

- **Key Observation**

- Basic computation in synthesis is **dot-product** of 3D textons' appearance vectors

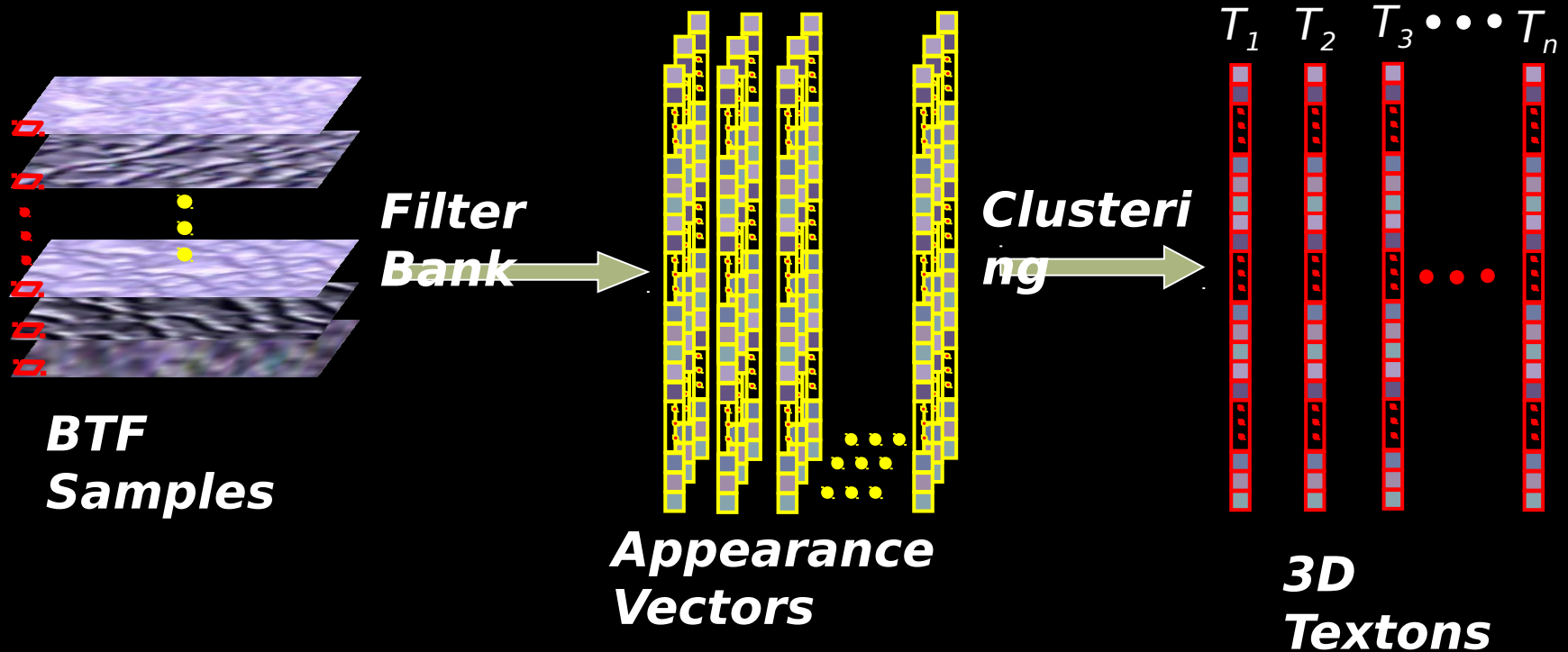
- **Solution**

- Pre-compute the dot-products and then discard all appearance vectors!

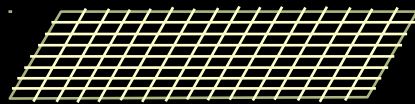
# ***Surface Texton***

- Surface Texton Space
  - Vector space spanned by 3D textons
- Surface Texton
  - Vector in surface texton space
  - Linear combination of 3D textons
- Dot-product Matrix
  - A look up table stores all dot products

# Texton Analysis



# Sample Texton Map



**Sample Texton  
Map**

$\hat{e}_{11}^T T_1$	$T_1 T_2$	L	$T_1 T_n$
$\hat{e}_{21}^T T_1$	$T_2 T_2$	L	$T_2 T_n$
$\hat{e}_{31}^T T_1$			$\vdots$
$\hat{e}_{n1}^T T_1$			$\vdots$
$\hat{e}_{12}^T T_2$	$T_1 T_2$	L	$T_1 T_n$
$\hat{e}_{22}^T T_2$	$T_2 T_2$	L	$T_2 T_n$
$\hat{e}_{32}^T T_2$			$\vdots$
$\hat{e}_{n2}^T T_2$			$\vdots$
$\hat{e}_{1n}^T T_n$	$T_1 T_n$	L	$T_1 T_n$
$\hat{e}_{2n}^T T_n$	$T_2 T_n$	L	$T_2 T_n$
$\hat{e}_{3n}^T T_n$			$\vdots$
$\hat{e}_{nn}^T T_n$			$\vdots$

**Dot-product  
Matrix**

**TEXTONS**

# Texton Analysis

